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Indian Standard

EXPRESSION OF PERFORMANCE OF AIR QUALITY INFRA-RED ANALYZERS

भारतीय मानक

वायु गुणता के इन्फ्रा-रेड विश्लेषकों की कार्यकारिता की अभिव्यक्ति

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Price Group 5

Electronic Measuring Equipment Sectional Committee, LTDC 21

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards on 21 June 1989, after the draft finalized by the Electronic Measuring Equipment Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

The object of this standard is to specify the terminology and definitions related to the functional performance of non-dispersive infra-red analyzers used for the continuous determination of certain aspects of air quality by measuring gaseous constituents either in ambient or confined atmospheres or in gaseous streams entering the ambient air; to unify methods used in making and verifying statements on the functional performance of such analyzers; and to specify what tests should be performed to determine the functional performance and how such tests should be carried out.

This standard is in accordance with general principles set out in IS 9176 : 1979 'Method for specifying the functional performance of electronic measuring equipment'.

While preparing this standard, assistance has been derived from IEC Pub 528 (1975) 'Expression of performance of air quality infra-red analyzers' issued by the International Electrotechnical Commission (IEC).

In reporting the result of a test made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

Indian Standard

EXPRESSION OF PERFORMANCE OF AIR QUALITY INFRA-RED ANALYZERS

1 SCOPE

1.1 This standard covers non-dispersive infra-red analyzers used for the continuous determination of certain aspects of air quality by measuring gaseous constituents either in ambient or confined atmosphere or in gaseous streams entering the ambient air.

1.2 It applies to infra-red analyzers specified for installation either indoors or outdoors.

1.3 It applies to the complete analyzer as an integral analytical unit, including all optical, mechanical, electrical and electronic portions. For the purpose of this standard, any regulated power supply provided with the analyzer or specified by the manufacturer, is considered part of the analyzer whether integral with the analyzer or housed separately.

1.4 It does not apply to the required sample handling systems or other accessories such as recorders, analogue-to-digital converters or data acquisition systems, used in conjunction with the analyzer.

1.5 Safety requirements are not dealt with in this standard.

2 REFERENCES

IS No.	*Title*
IS 9176 : 1979	Method for specifying the functional performance of electronic measuring equipment

3 TERMINOLOGY

3.0 For the purpose of this standard, following terms and definitions shall apply.

3.1 Calibration Gas

A mixture of known concentration of the component to be determined or a suitable simulant for the component to be determined in air another suitable carrier gas, used for the periodic calibration of the infra-red analyzer, and for various performance tests.

NOTES

1 For the purpose of this standard, concentrations means the mass or the volume of the component to be determined in a given volume of calibration gas. Different units may be used but the manufacturer shall state exactly what is meant by concentration.

2 For purpose of this standard, the concentrations of these gases represent the conventionally true values (*see* **3.6.2.1**) against which indicated values are compared. Therefore, the values of the calibration gases should be traceable to standards agreed upon by the manufacturer and the user or to national standards, and the uncertainty of conventionally true values shall be stated.

3.2 Influence Quantity

Any quantity, generally external to an apparatus, which may affect the performance of the apparatus.

3.3 Non-dispersive Infra-Red Analyzer

An electro-optical spectrophotometric instrument with no special dispersion component, consisting of a single or double source of infra-red radiation and one or more infra-red detectors separated by an optical cell or cells through one or more of which the sample flows whereby the specific spectral absorption of the component of interest is determined.

NOTES

1 For the purpose of this standard, the analyzer is adjusted by the manufacturer to select only the spectral band(s) at which the component to be determined has its characteristic absorption, and the sample cell length is appropriate for the rated range of concentration.

2 Specific spectral sensitivity is obtained by a selective component, such as, a selective source, selective detector or selective filter, or any combination of these components.

3.4 Performance Characteristic

One of the quantities assigned to an apparatus in order to define by values, tolerances, ranges, etc, the performance of the apparatus.

3.5 Terms Related to Conditions of Operation, Transport and Storage

3.5.1 *Reference Conditions*

A set of values with tolerances, or of restricted ranges of influence quantities, specified for making comparison and calibration tests.

3.5.2 *Rated Range of Use (of Influence Quantities)*

The range of values for an influence quantity within which the requirements concerning operating error are satisfied.

3.5.3 *Rated Operating Conditions*

The whole of the effective ranges for performance characteristics and rated ranges of use for influence quantities, within which the performance of the apparatus is specified.

3.5.4 *Limit Conditions of Operation*

The whole of the ranges of values for influence quantities and performance characteristics (beyond the rated ranges of use and effective ranges respectively) within which an apparatus may function without resulting in damage or degradation of performance when it is afterwards operated under rated operating conditions (*see* **4.2.3**).

3.5.5 *Conditions of Storage and Transport*

The whole of the conditions of temperature, humidity, air pressure, vibration, shock, etc, within which the apparatus may be stored or transported in an inoperative condition, without resulting in damage or degradation of performance when it is afterwards operated under rated operating conditions.

3.6 Terms Related to Specification of Performance

3.6.1 *Performance*

The degree to which the intended functions of an apparatus are accomplished.

3.6.2 *Error*

3.6.2.1 *Absolute error*

The error expressed algebraically, in the unit of the measured quantity. For measuring apparatus, the error is the indicated value of the measured quantity minus its true value.

NOTE — The true value of a quantity is the value that would be measured by a measuring process having no error. In practice, since this true value cannot be determined by measurement, a conventionally true value, approaching the true value as closely as necessary (having regard to the error to be determined), is used in place of the true value. This value should be traced to standards agreed upon by the manufacturer and the users, or to national standards. In both cases, the uncertainty of the conventionally true value shall be stated.

3.6.2.2 *Relative error*

The ratio of absolute error to a stated value.

3.6.2.3 *Percentage error*

The relative error expressed as a percentage, such as, percent of full scale (the maximum value of the effective range) and percent of the indicated or present value or of the rated value.

3.6.2.4 *Fiducial value*

A value to which reference is made in order to specify the percentage error, for example, the upper limit of the effective range, or another clearly stated value.

3.6.3 *Intrinsic Error*

The error determined under reference conditions.

3.6.4 *Operating Error*

The error determined under rated operating conditions.

3.6.5 *Influence Error*

The error determined when one influence quantity assumes any value within its rated range of use (or an influencing characteristic assumes any value within its effective range), all others being at reference conditions.

3.6.6 *Linearity Error*

The maximum deviation between actual analyzer readings and the readings predicted by a linear function of the measured quantity which includes the indicated values at the upper and lower limits of the effective range.

3.6.7 *Interference Error*

The error caused by interfering gases and vapours being present in the sample.

NOTE — This is an influence error and other influence errors are dealt with below.

3.6.8 *Limits of Error*

The maximum values of error assigned by the manufacturer to a measured quantity of an apparatus operating under specified conditions.

3.6.9 *Repeatability*

The deviation between repeated measurements made in rapid succession at the same concentration of the component to be determined under constant environmental conditions and rated sample conditions.

3.6.10 *Zero Drift*

The shift in reading for zero calibration gas (*see* **6.2**) over a stated period of time.

3.6.11 *Span Drift (Drift of the Limits of the Effective Range)*

The shift in span over a stated period of time.

3.6.12 *Operating Period*

The maximum time interval within which the limits of operating error are not exceeded, without adjustment by external means.

3.6.13 *Output Fluctuation*

Deviations from a mean output not caused by variation in the concentration of the component to be determined or by a change in any influence quantity.

3.6.14 *Minimum Detectable Concentration*

The concentration which corresponds to twice the output fluctuation level when the concentration of the component to be determined is zero.

3.6.15 *Delay Time*

The time interval from the instant a step change occurs in the concentration of the component to be determined at the analyzer inlet, to the instant when the change in the indicated value passes 10 percent of its steady-state amplitude, with the sample flow kept at its rated value.

3.6.16 *Rise (Fall) Time*

The time interval within which the indicated value passes from 10 percent to 90 percent (from 90 percent to 10 percent) of its steady-state amplitude after a step increase (decrease) in the concentration of the component to be determined at the analyzer inlet, with the sample flow kept at its rated value.

3.6.17 *Warm-Up Time*

The time interval after switching on the analyzer under specified conditions until the zero and span drifts are within specifications.

3.7 Values Related to Quantities

3.7.1 *Rated Value*

The value (or one of the values) of a quantity to be measured, observed, supplied or set which the manufacturer has assigned to the apparatus.

3.7.2 *Rated Range*

The range of a quantity to be measured, observed, supplied or set which the manufacturer has assigned to the apparatus.

3.7.3 *Effective Range*

That part of the rated range where measurements may be made within the stated limits of error.

4 PROCEDURE FOR STATEMENT

4.1 The manufacturer shall provide statements on the following.

4.1.1 The rated values for the performance characteristics listed in **4.3** shall be equal to their effective ranges.

4.1.2 The limits of errors listed in **4.4**.

4.1.3 The limits of drifts listed in **4.5**.

4.1.4 The performance characteristics listed in **4.6**.

4.1.5 The reference values or ranges, the rated ranges of use and the limit ranges of operation, storage and transport, for all influence quantities shall be stated and shall be selected from only one of the usage Groups I, II, or III in **5.1**. Any exceptions to the values given there shall be explicitly and clearly stated by the manufacturer with an indication that they are exceptions.

NOTE — Analyzers may correspond to one group of rated ranges of use for environmental conditions and to another group for mains supply conditions but this shall be clearly stated by the manufacturer.

4.2 Statements on rated operating conditions and limit conditions shall be made in such a way that the following requirements are met unless otherwise specified.

4.2.1 The analyzer, while functioning, shall show no damage or degradation of performance when any number of performance characteristics and/or influence quantities assume any value within the limit conditions of operation during a specified time or, if no time is specified, for an unlimited time.

4.2.2 The analyzer shall show no permanent damage or degradation of performance when, being inoperative, it has been subjected to conditions where any number of influence quantities assume any value within their storage or transport conditions during a specified time or, if no time is specified, for an unlimited time.

4.2.3 Absence of damage or degradation of performance means that after re-establishing regerence conditions or rated operating conditions, the analyzer again meets the requirements concerning its performance.

4.3 Performance Characteristics Requiring Statements of Rated Values

4.3.1 *Minimum and Maximum Rated Values for Concentrations of the Component to be Determined (Range or Ranges)*

The lower value is specified first, and then the upper value is specified (for example, 0 to 1 cm^3/m^3 or 10 to 20 mg/m^3).

4.3.2 *Minimum and Maximum Rated Values for Output Signals Corresponding to the Concentrations given in* **4.3.1**

These signals shall be stated in units of either voltage or current, and if multiple outputs are provided they shall be stated. If stated in units of voltage, the minimum allowable load, in ohms, shall also be stated. If stated in units of current, the maximum allowable load, in ohms, shall also be stated. If capacitive or inductive load will influence the output signal, this shall be specified.

NOTE — If the analyzer output signal is electrical current and more than one output range is supplied, the minimum and maximum rated values of one output range should be 4 and 20 mA, respectively.

4.3.3 *Rated Ranges for Sample Conditions at the Analyzer Inlet including Flow Rate, Pressure and Temperature*

4.4 Error Limits to be Stated

4.4.1 Operating error for the indicated concentration, expressed as concentration of the component to be determined (for example, ± 2 mg/m^3 or ± 1 cm^3/m^3), or as percent of full scale.

NOTE — For the purpose of this standard, the stated operating error will not include the effects of interference errors or the effects of variation in barometric pressure. They are stated separately and must be considered as additive to the operating error as stated by the manufacturer (*see* **4.4.3**, **4.4.3.1**, **4.4.3.2**, **6.7.2**, **6.7.2.1**, **6.7.2.2** and **6.7.8.1** relative interference errors; *see* **4.6.8** and **6.7.8.1** relative to the effect of barometric pressure variation).

4.4.1.1 Intrinsic error (which applies under reference conditions) may be stated in addition, for comparison and calibration purposes.

4.4.2 Linearity error for each specified range, expressed as percentage value in terms of the rated range of concentration (for example, ± 2 percent of full scale or − 2 percent of full scale).

NOTE — Deviation from linearity is strictly considered as an error only if a linear output signal is claimed for the analyzer. However, as a performance characteristic it should be included for comparison purposes and is referred to as an error in all cases for simplicity.

4.4.3 Interference errors for each specified range.

4.4.3.1 Interference errors shall be stated in terms of the equivalent concentration of the component to be determined for at least two concentration levels of the interference component. Depending on the design and adjustment of the analyzer, the interference error may be either positive or negative; therefore, the sign shall be included in the statement.

4.4.3.2 The manufacturer should indicate which components are known to have interference in the particular application under consideration. The specification of all interfering components for which interference errors are to be stated, and their concentration levels shall be made by agreement between the manufacturer and the user.

4.4.4 Repeatability error for each specified range, in terms of two standard deviations in the concentration of the component to be determined.

4.5 Zero drift and span drift, expressed as percentage values in terms of the rated range of concentration (for example, 2 percent of full scale) over a specified time interval. The time interval for which the drift limits are stated should be chosen appropriately for the specific application (for example, 1, 3 or 7 hours for automobile exhaust analyzers; 24 hours, 7 or 30 days for ambient air monitors). They should be chosen from the following:

15 minutes
1 hour
3 hours
7 hours
24 hours
7 days
30 days
3 months
6 months
1 year

These values are to be stated on the basis that no adjustments will be made on the analyzer by external means during the stated time intervals. The warm-up time is always excluded from the time interval.

4.6 Although no statements or error limits are required for the performance characteristics listed below, the manufacturer shall state their values or ranges.

4.6.1 *Output Fluctuation*

Expressed as a percentage value in terms of the rated range of concentration for the peak-to-peak deviation (for example, 0·25 percent of full scale).

4.6.1.1 In the case of analyzers having variable time constants in the output circuit, the output fluctuation shall be stated for the same time constant as used for the statement of delay time, rise time and fall time.

4.6.2 *Minimum Detectable Concentration*

4.6.3 *Delay Time*

4.6.4 *Rise Time*

4.6.5 *Fall Time*

4.6.6 *Warm-Up Time*

4.6.7 *Operating Period*

4.6.7.1 The time interval for the operating period shall be chosen from the same list as used for the zero drift.

4.6.8 *Quantitative Effect on Indicated Concentration Produced by Variation in Barometric Pressure*

NOTE — If the sample cell vents directly to the atmosphere, barometric pressure controls the pressure of the sample and thus the number of infrared absorbing molecules in the sample cell. Therefore, in the absence of any provision either to control the sample pressure independently of atmospheric pressure to sense the barometric pressure and apply a correction, the output signal corresponding to a given concentration will vary with the barometric pressure.

5 RECOMMENDED STANDARD VALUES AND RANGES OF INFLUENCE QUANTITIES

5.1 The rated ranges of use of the influence quantities have been divided into the following three usage groups (*see* **4.1.5**):

a) *Group I*

For indoor use under conditions which are normally found in the laboratories and factories and where apparatus will be handled carefully.

b) *Group II*

For use in environments having protection from full extremes of environment and under conditions of handling between those of Group I and III.

c) *Group III*

For outdoor use and in areas where the apparatus may be subjected to rough handling.

5.2 Climatic Conditions

5.2.1 *Ambient Temperature*

a) Reference value : 27°C (Unless otherwise specified by the manufacturer, according to IS 9176 : 1979).

b) Tolerance on reference value : ± 2°C.

c) Rated ranges of use Group I : + 5 to ± 40°C.

Group II : − 10 to + 55°C.

Group III : To be stated by the manufacturer.

d) Limit range of operation : Equal to the rated range of use unless otherwise stated by the manufacturer.

e) The limit range of change shall be stated by the manufacturer.

f) Limit range for storage and transport : − 40 to + 70°C.

5.2.2 *Relative Humidity of the Air*

Because extreme values of both temperature and humidity are not likely to occur simultaneously, the manufacturer may specify the time limit over which these may be applied and shall specify the limitations of the combination, if any, for continuous operation.

a) Reference range at 23°C : 45 to 75 percent.

b) Rated ranges of use

Group I : 20 to 80 percent excluding condensation.

Group II : 10 to 90 percent including condensation.

Group III : To be stated by the manufacturer.

c) Limit range of operation : Equal to the rated range of use unless otherwise stated by the manufacturer.

d) Limit range for storage and transport : To be stated by the manufacturer.

5.2.3 *Barometric Pressure*

a) Reference value : 101·3 kPa.

b) Rated ranges of use :

1) Group I and II : ± 5 percent of any mean local barometric pressure between 70·0 to 106·0 kPa.

2) Group III : To be stated by the manufacturer.

Regarding the effect of the barometric pressure of the sample, *see* **4.4.1**, **4.6.8** and **6.7.8.1**.

c) Limit range of operation : Equal to the rated range of use unless otherwise stated by the manufacturer.

d) Limit range for storage and transport : To be stated by the manufacturer.

5.2.4 *Heating Effect Due to Solar Radiation*

a) Reference value : No direct irradiation.

b) Rated ranges of use :

1) Group I and II : No direct irradiation.

2) Group III : To be stated by the manufacturer.

c) Limit range of operation : Equal to the rated range of use unless otherwise stated by the manufacturer.

d) Limit range for storage and transport : To be stated by the manufacturer.

5.2.5 *Velocity of the Ambient Air*

a) Reference range : 0 to 0·2 m/s.

b) Rated ranges of use :

1) Group I and II : 0 to 0·5 m/s.

2) Group III : To be stated by the manufacturer.

c) Limit range of operation : Equal to the rated range of use unless otherwise stated by the manufacturer.

5.2.6 *Sand and Dust Contents of the Air*

a) Reference value : No measurable contents

b) Rated ranges of use :

1) Group I and II : Negligible contents (that is, will have negligible effect on the analyzer).

2) Group III : To be stated by the manufacturer.

c) Limit range of operation : Equal to the rated range of use unless otherwise stated by the manufacturer.

d) Limit range for storage and transport : To be stated by the manufacturer.

5.2.7 *Salt Contents of the Air*

a) Reference value : No measurable contents.

b) Rated ranges of use :

1) Group I and II : Negligible contents.

2) Group III : To be stated by the manufacturer.

c) Limit range of operation : To be stated by the manufacturer.

d) Limit range for storage and transport : To be stated by the manufacturer.

5.2.8 *Contaminating Gas or Vapour Contents of the Air*

a) Reference value : No measurable contents.

b) Rated ranges of use :

Group I to III : To be stated by the manufacturer.

c) Limit range of operation : To be stated by the manufacturer.

d) Limit range for storage and transport : To be stated by the manufacturer.

5.2.9 *Liquid Water Contents of the Air*

a) Reference value : No measurable content.

b) Rated ranges of use :

1) Group I : Negligible contents.
2) Group II : Drip water.
3) Group III : Splash water.

c) Limit range of operation : To be stated by the manufacturer.

d) Limit range for storage and transport : To be stated by the manufacturer.

5.3 Mechanical Conditions

5.3.1 *Operating Position*

a) Reference value : Position as stated by the manufacturer.

b) Tolerance on reference value : ± 1°.

c) Rated ranges of use :

1) Group I and II : Reference position ± 10°.
2) Group III : To be stated by the manufacturer.

d) Limit range of operation : To be stated by the manufacturer.

e) Limit range for storage and transport : To be stated by the manufacturer.

5.3.2 *Ventilation*

a) Reference value : Ventilation not obstructed.

b) Rated ranges of use :

1) Group I and II : Negligibly obstructed.
2) Group III : To be stated by the manufacturer.

c) Limit range of operation : To be stated by the manufacturer.

5.3.3 *Vibration*

a) Reference value : No measurable value.

b) Rated ranges of use :

1) Group I : Negligible value.
2) Group II and III : To be stated by the manufacturer.

c) Limit range of operation : To be stated by the manufacturer.

d) Limit range for storage and transport : To be stated by the manufacturer.

5.3.4 *Mechanical Shock*

a) Reference value : No measurable value.

b) Rated ranges of use :

Group I to III : To be stated by the manufacturer.

c) Limit range of operation : To be stated by the manufacturer.

d) Limit range for storage and transport : To be stated by the manufacturer.

5.3.5 *Sound Pressure*

a) Reference value : No measurable value.

b) Rated ranges of use :

Group I to III : To be stated by the manufacturer.

c) Limit range of operation : To be stated by the manufacturer.

d) Limit range for storage and transport : To be stated by the manufacturer.

5.4 Mains Supply Conditions

5.4.1 *Mains Supply Voltage* (considering a distorted waveform)

Reference Value	*AC (rms) Rated Value* %	*(AC peak) Rated Value* %
Tolerance on reference value	± 1	± 2
Rated ranges of use		
Group I	± 10	± 12
Group II	− 12 to + 10	− 17 to + 15
Group III	− 20 to + 15	− 30 to + 25

Limit range of operation : Equal to be rated ranges of use unless otherwise stated by the manufacturer.

5.4.2 *Mains Supply Frequency*

a) Reference value : Rated frequency.

b) Tolerance on reference value : ± 1 percent.

c) Rated range of use :

1) Group I and II : ± 5 percent.
2) Group III : ± 10 percent.

5.4.3 *Distortion of AC Mains Supply*

The distortion is determined by a factor β in such way that the waveform is inside an envelope, formed by :

$$y_1 = (1 + \beta) \quad A \sin \omega t$$

$$y_1 = (1 - \beta) \quad A \sin \omega t$$

a) Reference value : $\beta = 0$ (sine wave)

b) Tolerance on reference value : $\beta = 0·05$

c) Rated ranges of use :

Group I : $\beta = 0·05$
Group II : $\beta = 0·10$
Group III : β = To be stated by the manufacturer.

d) Limit range of operation : To be stated by the manufacturer.

The values of β are valid when the analyzer is connected to the supply mains.

NOTES

1 The above formula may be applied over the half cycle or a full cycle depending on whether the zero crossings are equally spaced or not.

2 If the ac peak voltage exceeds the voltage stated in 5.4.1, the mains supply under consideration cannot be used.

6 VERIFICATION OF VALUES

6.1 Compliance tests shall be performed with the analyzer ready for use (including accessories) after warm-up time and after performing adjustments according to the manufacturer's instructions.

6.1.1 In general, measurements for verification shall be carried out with instruments which do not appreciably (or only calculably) affect the value to be measured. In principle, the errors in measurements made with these instruments should be negligible in comparison with the errors to be determined (*see also* **6.2**).

6.1.2 When the error of the instrument is not negligible, the following rule should apply:

> If an analyzer is claimed to have a limit error of ± e percent for a given performance characteristic and the manufacturer uses for its checking an instrument resulting in an error of measure ment of ± n percent, the error checked shall remain between the limits ± ($e - n$) percent.
>
> Likewise, if a customer checks the same analyzer using another instrument resulting in an error of measurement of ± m percent, he is not entitled to reject the analyzer if its apparent error exceeds the limits ± e percent but remains between the limits ± ($e + m$) percent.

6.1.3 Unless otherwise specified, the influence quantities shall be at reference conditions during the test concerned.

NOTE — The concentration representing nearly full scale should be within 90 percent of full scale.

6.2 Test equipment shall include at least five calibration gases for each specified range, one representing zero, one representing full scale, and three of approximately evenly spaced intermediate values of concentrations of the component to be determined, all traceable to standards agreed upon by the manufacturer and the user or to be national standards, with stated uncertainty of concentration values. The uncertainty of these concentration values should be considered in the same manner as the error of a testing instrument.

6.3 During tests, adjustment by external means may be repeated at the intervals prescribed by the manufacturer or at any suitable interval if such adjustment does not interfere with the error to be checked. Adjustments will also be performed when error values have expressly been quoted to be valid only after such adjustment. Measurements shall then be made immediately after such adjustment so that any drift will not influence them.

6.4 When measuring the intrinsic error of a performance characteristic, the combination of values and/or ranges of influence quantities shall remain within the reference conditions which include relevant tolerance on reference values.

6.5 When measuring the operating error of a performance characteristic, the combination of values and/or ranges of influence quantities may vary to the limits of the rated operating conditions.

6.6 When measuring the influence error of a performance characteristic due to an influence quantity, all other influence quantities shall remain within reference conditions. The relevant influence quantity may assume any value within its rated range of use.

6.7 Testing Procedures

6.7.1 *Linearity Error*

The analyzer is flushed with zero calibration gas, nearly full scale calibration gas and at least three intermediate calibration gases whose concentrations are approximately uniformly distributed over the rated range of concentration. The analyzer output readings are plotted versus the calibration gas concentrations, on linear graph paper. These steps are performed three times and a bestfit curve is drawn through all points after which the linearity error is determined in terms of concentration of the component to be measured.

6.7.2 *Interference Error*

Interference error should be determined for each component which is known to interfere with the component to be measured and which is expected to be in the sample stream at sufficient concentration to produce an appreciable error equal to or greater than the minimum detectable concentration in the desired determination. Generally, the interference error should be determined for the highest expected concentration of the interfering component and also for a specified concentration at approximately half that level. The specific interfering components and their concentration levels for testing and statement of interference errors shall be specified for each application by agreement between the manufacturer and the user. However, the manufacturer bears an obligation to indicate those components which he expects, from experience, to be in the specific stream at sufficient concentration to produce interference equal to or greater than the minimum detectable concentration (for example, water vapour in most applications).

NOTE — Since interference errors are generally of second order, the required precision for interference testing gas concentrations is much less than that for calibration gases.

6.7.2.1 The interference errors are determined by first flushing the analyzer with zero calibration gas and then sequentially with gases which contain the two concentrations of interfering components and which are otherwise identical to the zero calibration gas (recording output signal for each gas). Each test is repeated in terms of the equivalent concentration of the component to be determined.

6.7.2.2 Water vapour interference error can be determined as follows:

> The analyzer is flushed with zero calibration gas which is either known to be dry (that is less than 0·1 percent water vapour by volume) or passed through a drying tube before entering the analyzer. Then the instrument is flushed with the same zero calibration gas passed through a water bubbler ahead of the analyzer. The bubbler temperature is adjusted to provide the desired water vapour pressures that represent the desired concentrations. The procedure is as stated in **6.7.2.1**.

6.7.3 *Repeatability Error*

The analyzer is flushed with zero calibration gas until a constant reading is obtained (not recorded). Then it is flushed with a calibration gas that gives a reading between 70 and 90 percent of full scale until a constant reading is obtained (and recorded). These steps are repeated six times. The recorded readings are converted to concentration units and the standard deviation is calculated.

6.7.4 *Zero Drift and Span Drift*

The analyzer is flushed with zero calibration gas until constant reading is obtained. The reading is adjusted to approximately 5 percent of scale and recorded. The analyzer is then flushed with a calibration gas that gives a reading between 75 and 95 percent of full scale and the difference between that reading and the zero calibration gas reading (span) is recorded. These steps are repeated after the specified time interval (*see* **4.5**) and the zero and span drift errors are calculated and recorded as percentage values in terms of the rated range of the concentration.

6.7.5 *Output Fluctuation*

The reading of the analyzer is adjusted as in **6.7.4** and flushing with zero-calibration gas is continued for 5 minutes. The maximum peak-to-peak value of the random or regular deviations from the mean output is determined in terms of percent of full scale. The test is repeated three times and the average of the readings is recorded.

NOTE — For the purpose of this standard, spikes caused by the influence of external electromagnetic fields or by supply mains spikes are considered as being due to changes in influence quantities and are therefore ignored in the determination of output fluctuation.

6.7.6 *Delay Time, Rise Time and Fall Time*

With a recorder connected to its output terminal, the analyzer is flushed zero-calibration gas at the rated flow rate until a constant reading is obtained. Then a calibration gas that gives a reading between 70 to 90 percent of full scale is introduced at the analyzer inlet port at the rated flow rate and a mark is made on the recorder chart. Gas flow is continued until a constant reading is obtained. Zero — calibration gas is introduced at the analyzer inlet port at the rated flow rate and a mark is made on the recorder chart. Gas flow is continued until a constant reading is obtained. The values for delay time, rise time, and fall time are determined from the chart through knowledge of the recorder chart speed.

6.7.7 *Warm-Up Time*

The analyzer is switched off and all of its components are allowed to cool to the reference temperature. The analyzer is switched on and flushed immediately with calibration gas that gives a reading between 75 and 95 percent of full scale, and the reading is recorded. The operation of flushing and recording is continued until the deviation in reading over 30 minutes is not greater than the stated repeatability error. Warm-up time is determined as the interval from the time when the analyzer is switched on until 30 minutes before the equilibrium conditions are met.

NOTE — If necessary, to keep the readings on scale, the zero may be adjusted during the time of significant changes in the reading.

6.7.8 *Operating Period*

6.7.8.1 The test for operating period is the most comprehensive test included for the verification of values stated by the manufacturer for the performance of non-dispersive infra-red analyzer. It represents the combination of values which constitute the worst case and thereby substitute for complete verification of operating error.

Two important influence quantities which are not tested are the effect of interference errors and the effect of barometric pressure which should be considered separately. Interference errors are considered separately since they will depend on the specified components and concentration ranges agreed upon by the manufacturer and the user for each specific application (*see* **4.4.3**, **4.4.3.1**, **4.4.3.2**, **6.7.2**, **6.7.2.1** and **6.7.2.2**). The effect of barometric pressure is considered separately since it would be very difficult to control a barometric pressure during a test. The effect on indicated concentration produced by changes in barometric pressure must be stated by the manufacturer and in performing this compliance test, the barometric pressure must be recorded when readings are taken so that appropriate corrections can be applied (*see* **4.4.1** and **4.6.8**).

6.7.8.2 This test is performed under reference conditions except as otherwise stated in **6.7.8.4**. At no time after the start of the test, may the analyzer be adjusted by external means. The analyzer is calibrated according to the manufacturer's instructions immediately before starting the test, and it is operated according to the manufacturer's instructions during the test.

6.7.8.3 The analyzer is flushed with a calibration gas that gives a reading between 70 and 90 percent of full scale and the reading is recorded in terms of concentration of the component to be determined.

The analyzer is operated for at least the stated operating period and readings on the calibration gas are taken at intervals of, at the most, one-fifth of the stated operating period if it is one hour or less, or intervals of, at the most, one-tenth of the stated operating period if it is three hours or more.

After correction for barometric pressure effect, all readings taken within the stated operating period must agree with the conventionally true value of the calibration gas concentration within the stated operating error (*see* **3.1**, **3.6**, **3.6.3**, **4.4.1** and **6.2**).

6.7.8.4 Conditions under which the test is performed are reference conditions, except as follows:

The supply voltage must be at the minimum value of the stated limit range of operation when at least one reading is taken on the calibration gas and at the maximum value of the limit range of operation when at least one other reading is taken on the calibration gas. Like wise, the supply frequency must be at the minimum value of the stated limit range of operation for one reading and at the maximum value for another. The deviations in voltage and frequency from their reference values should not be simultaneous.

If the operating period is three hours or more, the ambient temperature shall be at the minimum value of the stated limit range of eopration when one reading is taken on the calibration gas and at the maximum value of the stated limit range of operation when another reading is taken on the calibration gas. The deviation of ambient temperature from its reference value should not be simultaneous with the deviation in either voltage or frequency from their reference values. The rate of change of ambient temperature should not exceed the limit rate of change stated by the manufacturer (*see* **5.2.1**).

NOTE — In order for the statements of :

a) limit range of operation of ambient temperature,

b) limit rate of change for ambient temperature, and

c) operating period

to be consistent and acceptable, (a) shall not be greater than the product of (b) times (c) (for example, if the limit rate of change for ambient temperature is 5°C/h and the stated operating period is 10 hours, the limit range of ambient temperature cannot be greater than 50°C.

If necessary, in order to complete the three tests involving changing the operating conditions, according to the above procedure, a second operating period test will be performed in order to include all of them.

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